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Exploring portfolio diversification opportunities in Islamic capital markets through bitcoin: evidence from MGARCH-DCC and Wavelet approaches

Lim Siok Jin¹ and Mansur Masih²

Abstract

Bitcoin is a form of digital currency that is circulating without the backing of any central bank and monitoring authority. Therefore, sceptics regularly question the status of Bitcoin as a legal tender. Nevertheless, due to increasing popularity and importance of Bitcoin, practitioners and researchers have recently started to assess Bitcoin from the perspective of business, economics and finance. This paper explores possibilities of using Bitcoin as a portfolio optimisation strategy for Islamic fund managers. We use three recent and appropriate methodologies: M-GARCH-DCC, Continuous Wavelet Transforms (CWT), and Maximum Overlap Discrete Wavelet Transform (MODWT). The results significantly tend to indicate that Bitcoin and Shari'ah stock indices are lowly and negatively correlated, suggesting that Islamic stock investors can benefit from diversification with Bitcoin and that the fundamentals of such crypto-currencies can be further investigated for the benefit of Islamic capital markets.

Keywords: Islamic stocks, Bitcoin, portfolio diversification, MGARCH-DCC, Wavelets

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1. Introduction

In recent years, where cashless transactions and internet banking are the norm in the society, one would wonder if money would be in paperless form in time to come. In one of the largest economies in the world, China, a recent survey shows that 70% of citizens in the country no longer require cash in daily transactions (The Times UK, 2017). Hence, our attention is drawn to the largest and most popular digital currency in use at the moment which is Bitcoin, a decentralized system introduced by Nakamoto (2008). In parallel, many recent articles on Bitcoin classify it as an alternative to the fiat currency, one that is not backed by any government or central banks (Weber, 2014). The introduction of this form of currency is during the 2008 financial crisis which only makes it more controversial in the financial system. A more detailed explanation by Dwyer (2015) on Bitcoin looked into its potential and comparison with existing currencies and gold prices. A form of cryptocurrency, Bitcoin has advantages that allowed it to prevail over sceptics with its low/zero fee, a controlled and known algorithm for creation of currency, and information transparency. Bitcoin is just one of the many digital currencies available in the digital world, but one that is by far the largest in market capitalization of approximately USD29 billion as of May 2017 (Coinmarketcap, 2017).

Popularity of Bitcoin grew as users capitalise on the advantages of the digital currency especially online businesses in boosting sales even though Bitcoin does not have a legal tender status. Alongside the advantages, some users have been making use of Bitcoin for money laundering purposes, hacking, speculating, organized crime and potentially terrorist financing. As users grew, researchers too are becoming more interested in the fundamentals, economics and finance of Bitcoin. The fundamentals of Bitcoin were studied and several studies have concluded that the characteristics of Bitcoin resemble a speculative instrument rather than a currency for long term holding (Bucholz et al. 2012; Kristoufek 2013; Ciaian et al. 2014; Yermack 2014; Bouoiyour et al. 2015; Bouoiyour and Selmi 2015). This however does not deter Rogojanu and Badea (2014) from studying the potentials of Bitcoin as an alternative monetary system. To further understand the determinants of Bitcoin prices, Brandvold et al. (2015) and Ciaian et al. (2016) found that the presence of Bitcoin exchange and oil price has significant impact. Bouri et al. (2016) studied the Bitcoin trade volume, volatility and returns while Balcilar et al. (2016) focused on the persistence of its volatility. Despite multiple criticism on the validity of Bitcoin as a storage of value, the launch of Winklevoss Bitcoin Trust as a Bitcoin ETF proved otherwise (Baluchnas, 2013;

Arash and Alloway, 2013; Arthur, 2013). Brière et al (2015) are among the earlier researchers that looked into Bitcoin as a potential diversification tool in place of conventional currencies. Among its argument are that the creation of Bitcoin though is unregulated by any central depository, followed the rule of gold markers where Bitcoin “miners” are paid in the form of digital currencies for solving sophisticated mathematical problems. This in turn led to the study by Bouri et al (2017) that looked into energy inputs required by “miners” and incentives of mining for Bitcoin depending on energy prices. Hence, the impact of Bitcoin to the society cannot be underestimated as its linkage to energy (a form of commodity) opens up its potential to be included in equity portfolios as a diversifier (Halaburda and Gandal, 2014; Eisl et al., 2015). The difference between a diversifier, hedge and safe haven is clearly explained by Bouri et al (2017) prior to studying the behaviour of Bitcoin. The result found that Bitcoin is more of a diversifier. Fast forward, several articles in 2012 and 2013 analysed Bitcoin from financial economics perspective as 2013 is when trading volumes has soared multiple folds since its introduction.

Besides growing interest in cryptocurrencies, the 2008 crisis also sparked interest in the field of profit and loss sharing (PLS) principles of Islamic finance. The compliance to Shari’ah may well be an added advantage to protect against financial bubbles. Malaysia is among the leader in Islamic finance and by implementing it in a larger scale through introduction of the KLCI Shari’ah index in the year 1999, Sarif (2011) noted that the Islamic finance industry has grown 14% annually in the last 15 years, hence it gives greater incentives to look into the Shari’ah compliant equities that are mostly listed in Shari’ah indices all over the world. Inspired by the use of recently developed techniques and research on portfolio diversification for Islamic investors, Jaffar & Masih (2014); Najeeb et al(2015); Rahim & Masih (2016) have provided a fundamentally strong starting point for further research in Islamic equities and indices.

With past studies on Bitcoin as a potential investment portfolio diversifier, we intend to add on to existing literatures by combining Shari’ah compliant equities to identify potential diversification through the ever so popular cryptocurrency. A statement by the Central Bank of Malaysia warned the public that Bitcoin is not a legal tender in the country (BNM, 2014). In addition to that, Shari’ah scholars may have further criticism on Bitcoin being non-Shari’ah compliant. Nevertheless, this study intends to look beyond these claims and identify

the potential of Bitcoin for Malaysian and non-Malaysian Shari'ah investors who want to diversify their portfolios.

2. Literature Review

First and foremost, we would like to justify the validity and Shari'ah compliance of Bitcoin as a potential diversification tool. Whilst research in this new medium of currency is limited, Evans (2015) explains how Bitcoin or a similar blockchain management system can comply with the Shari'ah requirements and could be a better medium of exchange than fiat currencies.

Research on Bitcoin and its potential as a diversification tool started by earlier studies looking into its correlation with commodities. Bouri et al (2016) used dynamic conditional correlations method and identified diversification properties of Bitcoin for major world stock indices, bonds, oil, gold, US Dollar and general commodities. Brière et al (2015) found the same results. Kristoufek (2015) then used wavelet coherence method to observe potential drivers of Bitcoin prices, and concluded that fundamental economic factors affect its price. The research also were in line with Bouri et al (2016) that Bitcoin is not a safe haven investment and has a combination of properties from financial assets and speculative bubbles. Findings by Eisl et al (2015) using Conditional Value-at-risk framework was confirmed by Bouri et al (2016) and further recommends that Bitcoin to be included in optimal portfolios .

Bouri et al (2017) in another recent article used wavelet-based quantile-in-quantile regressions observed ability of Bitcoin to hedge against uncertainty at higher quantiles and lower frequencies. Dhyrberg (2015) adds that Bitcoin share some hedging abilities with gold and can hedge against stocks in the Financial Times Stock Exchange Index and short term USD currency. Bouoiyour et al (2016) used Empirical Mode Decomposition (EMD) method and found that Bitcoin is in fact driven by long-term fundamentals rather than short-term and speculative.

In the Islamic stock markets, multiple studies have been done using latest techniques. Among them are by Najeeb et al (2015) looked at potential cross border diversification for Islamic investors in Malaysia and concluded that developed markets, European markets and MENA are better for diversification. The findings from this study partially influenced the decision of using Dow Jones Islamic Developed Markets index and Dow Jones Islamic European Market index in the research. MENA however was excluded in our study as we feel

that more studies should be done despite offering good diversification properties. Dow Jones Islamic Emerging Markets index instead were used to capture a broad market-wise portfolio diversification, while European index to capture region-wise diversification. Rahim & Masih (2016) employed similar methods of MGARCH-DCC and Wavelet to study diversification opportunities for Malaysian Islamic investors to diversify with Shari'ah indices of the country's major trading partners. Jaffar & Masih (2014) innovatively used Malaysian Ace Index to represent venture capital (PLS investments) which are the fundamentals of Islamic investments and found portfolio optimisation opportunities for investors in other Shari'ah stock indices in Malaysia.

The methods used in these studies are not unpopular and has been used in other articles looking at diversification opportunities in markets other than Malaysia and Shari'ah indices. For example, Kearney & Poti (2006) used MGARCH-DCC to study determinants of volatility of equity returns in major Euro-zone indices. Paramati et al (2013) found long-run relationship between Australia and its major trading partners allowing potential diversification for portfolio managers. Gjika & Horvath (2013) used asymmetric DCC model in their study which identified correlations of stock markets in central Europe. While Bitcoin and Islamic equity markets has grown in popularity, the existing literatures has so far overlooked the potential role of Bitcoin as a form of diversification for Islamic investors. This paper intends to fill the literature gap by looking into potential diversification of Bitcoin in the Islamic equity markets.

3. Research Objectives and Contributions

We know from past literatures that Islamic fund investors in Malaysia will benefit from diversifying their investments in international stock indices and certain commodities, but we intend to see if Bitcoin can be a diversification tool in addition to the others.

1. Can the Malaysian Islamic stock market investors gain portfolio diversification benefit by investing in Bitcoin?
2. Of the few indices recommended for diversification in previous articles, which will benefit from investing in Bitcoin?
3. How would diversification benefits with Bitcoin change given different investor stockholding periods (e.g., two to four days, four to eight days, eight to sixteen days, etc.)?

The results from each of the research questions are expected to have significant impact on investors and fund managers in their decisions concerning portfolio allocations and investment horizons with the presence of technology and cashless transactions. More importantly, the results will help in addressing the newly emerging issue of whether cryptocurrency is stable enough to provide portfolio diversification and whether these benefits change given different investment holding periods.

4. Methodology

The study implements the multivariate GARCH DCC (MGARCH-DCC) and wavelet tools namely wavelet coherency to capture the correlation between two time series (i.e., CWT and MODWT).

Multivariate GARCH – Dynamic Conditional Correlation (MGARCH-DCC)

MGARCH-DCC approach allows the researcher to observe and analyse the precise timings of shift in conditional correlations and volatilities. The main merit of DCC in relation to other time varying methods such as Kalman filters and Flexible Least Squares is that it accounts for changes in both the mean and variances of the time series. In other words, DCC allows for changes both in the first moment (mean) and the second moment (variance). Estimation of MGARCH-DCC involves two step processes to simplify the estimation of time varying correlations. In first stage, univariate volatility parameters are estimated by using GARCH model. In stage two, the standardized residuals from first stage are used as inputs for estimating a time varying correlation matrix.

$$H_t = D_t R_t D_t$$

H_t : Conditional covariance matrix

D_t : Diagonal matrix of conditional time varying standardized residuals

R_t : Time varying correlation matrix

Wavelet

The wavelet approach allows us to identify stock market interactions that are challenging to be tested out using any other modern econometric time-series models. As we know, markets consist of traders operating in different time horizons and therefore these traders can behave differently depending on non-similar time resolutions (daily, monthly, and weekly). These are the few advantages of using wavelet approach. First of all, wavelets can be used to overcome the problems due to non-stationarity of the series signals. Secondly, wavelet can be a very useful technique for analysing financial relations especially when there is a distinction between short and long-run relations. Wavelets are localized in both time and scale (frequency band) and can be used to decompose any observed variable on scale by scale (different frequency bands) basis in order to analyze the dynamics of co-movement across different time horizons without losing any information. The main advantage of the cross-wavelet coherency-phase analysis is its ability to analyze transient dynamics for the association between two time series.

i) Continuous Wavelet Transform (CWT)

For the wavelet decomposition, this study follow the studies of Grinsted et al. (2004) and Aguiar-Conraria and Soares (2011) which apply wavelet coherency in the form of continuous wavelet transform (CWT) on the return series in order to capture co-movement in time-frequency space. The continuous wavelet transform of a time series x_t with respect to ψ is a function of two variables given by the following convolution:

$$W_x(\tau, s) = \int_{-\infty}^{+\infty} x(t) \bar{\psi}_{\tau, s}(t) dt = \frac{1}{\sqrt{s}} \int_{-\infty}^{+\infty} x(t) \bar{\psi}\left(\frac{t - \tau}{s}\right) dt,$$

where the bar denotes the complex conjugate, τ is the time position or translation parameter controlling its location, s is the scale or dilation parameter that controls the width of the wavelet, and $1/\sqrt{s}$ is a normalization factor to make sure that the wavelet transforms are comparable across scales and time series.

ii) **Maximum Overlap Discrete Wavelet Transform (MODWT)**

Maximum Overlap Discrete Wavelet Transform (MODWT) is used with its advantage on the flexibility of the length of data which means not requiring the integral power of 2, as well as the time invariant property. The wavelet family symmlet 8 is chosen in order to get the least asymmetry property, which is more appropriate for financial series. The transformed return series $r(t)$ is represented as a linear combination of wavelet functions as follows:

$$r(t) = \sum_k s_{j,k} \phi_{j,k}(t) + \sum_k d_{j,k} \psi_{j,k}(t) + \sum_k d_{j-1,k} \psi_{j-1,k}(t) + \dots + \sum_k d_{1,k} \psi_{1,k}(t),$$

where:

j is the number of scale crystals (intervals or frequencies);

k is the number of coefficients in the specified component;

$\phi_{j,k(t)}$ and $\psi_{j,k(t)}$ are the father and mother orthogonal wavelet pair that are given respectively by:

$$\begin{aligned}\phi_{j,k}(t) &= 2^{-j/2} \phi\left(t - \frac{2^j k}{2^j}\right) \\ \psi_{j,k}(t) &= 2^{-j/2} \psi\left(t - \frac{2^j k}{2^j}\right)\end{aligned}$$

Father wavelets represent the low-frequency (smooth) parts of the series, whereas mother wavelets represent the high-frequency (detailed) parts of the series. $s_{j,k}$ and $d_{j,k}$ are wavelet coefficients that are approximated by the following integrals:

$$\begin{aligned}\int \phi_{j,k}(t) f(t) dt &\approx s_{j,k} \\ \int \psi_{j,k}(t) f(t) dt &\approx d_{j,k}\end{aligned}$$

$s_{j,k}$ are called the ‘smooth’ coefficients that represent the underlying smooth behavior of the series, while $d_{j,k}$ are called the ‘detail’ coefficients that represent the scale deviations from the smooth process. These coefficients are the measures of the contribution of the corresponding wavelet function to the total series. After decompose the return series into j crystals, the crystals

d_j are recomposed into a time domain. The entire excess return series is replicated in multi-resolution decomposition as follows:

$$\hat{r}^J = D_1 + \dots + D_J + S_J$$

D_j is the recomposed series in the time domain from the crystal d_j and S_J is the recomposition of the residue. The reconstituted return series \hat{r}^J contain the separate components of the original series at each frequency j . D_j represent the contribution of frequency j to the original series. After obtaining the recomposed series for each frequency, the study follows Ramsey and Lampart (1998) in estimating beta in different time scales. The coefficient β_i the key variable the study are trying to examine, which change depending on the timescale j . The study can estimate wavelet covariance $\tilde{\gamma}_{XY}(\lambda_j)$ and wavelet variance, $\tilde{\sigma}_X(\lambda_j)$ and $\tilde{\sigma}_Y(\lambda_j)$. For correlation, the wavelet correlation coefficient, $\rho_{XY}(\lambda_j)$, provides a standardized measure of the relationship between the two time series subjected to multiple timescales. The unbiased estimator of the wavelet correlation for timescale j is defined by

$$\tilde{\rho}_{XY}(\lambda_j) = \frac{\tilde{\gamma}_{XY}(\lambda_j)}{\tilde{\sigma}_X(\lambda_j)\tilde{\sigma}_Y(\lambda_j)}$$

where, $\tilde{\sigma}_X(\lambda_j)$ and $\tilde{\sigma}_Y(\lambda_j)$ are the unbiased estimators of the wavelet variances while $\tilde{\gamma}_{XY}(\lambda_j)$ is the unbiased estimators of the wavelet covariance. The study follow Gencay et al. (2002) for a simple wavelet-based approach to testing for significant difference. In particular, the study will test whether wavelet correlation coefficients on a scale-by-scale basis between Islamic and conventional pairs are significantly different. The significant change is identified by observing approximate confidence intervals between Islamic and conventional pairs. The null hypothesis of no statistically significant difference can be rejected when 95% approximate confidence intervals are non-overlapping.

Symbol	Definition
FBMSHA	FTSE BURSA MALAYSIA EMAS SHARIAH - PRICE INDEX
DJIU	DJ ISLAMIC EUROPE - PRICE INDEX
DJIDEV	DJ ISLAMIC WORLD DEVELOPED - PRICE INDEX
DJIEM	DJ ISLAMIC WORLD EMERGING MKTS. - PRICE INDEX
BITCOIN	BITCOIN

Table 1: Selected indices for research

5. Results & Discussions

Past articles by Jaffar & Masih (2017), Najeeb et al (2015) and Rahim & Masih (2016) have consistently used FTSE Bursa Malaysia Emas Shari'ah Index as a proxy for Malaysian Shari'ah stock index return. This study will apply the same index as a proxy for Malaysian Shari'ah stocks (FBMSHA) along with Dow Jones Islamic Developed Markets (DJIDEV), Dow Jones Islamic Emerging Markets (DJIEM) & Dow Jones Islamic Europe (DJIU).

We collected daily closing price data for all 5 indices from 1 Jan 2013 – 2 Jan 2017. All stock market indices are obtained from Thomson-Reuters DataStream database and Bitcoin price index obtained from Coindesk, which is currently the most active Bitcoin exchange. Returns from all 5 indices are calculated as differences of the logarithmic daily closing prices of indexes, $\{\ln(pt) - \ln(pt-1)\}$, where p is an index value.

The descriptive statistics in Table 2 below show that the volatility of returns represented by the standard deviation is the highest for the Bitcoin index and lowest for the FTSE Bursa EMAS Malaysia returns. This standards deviation shows absolute time independent volatility of the return. At the same time, mean is also highest for BITCOIN. We also observed that all returns are negatively skewed except for the returns of Bitcoin index, portraying an asymmetric return. Notice that kurtosis value of all indices are above 3 indicating a fat-tail distribution and all are not normally distributed.

Sample period	: 1045 observations from 01-Jan-13 to 02-Jan-17				
Variable(s)	: BITCOIN	DJIDEV	DJIEM	DJIU	FBMSHA
Maximum	: .49966	.025962	.075080	.037803	.032472
Minimum	: -.35071	-.041938	-.066263	-.064264	-.033693
Mean	: .0041361	.2619E-3	-.1137E-3	.2596E-4	.4015E-4
Std. Deviation	: .055926	.0070534	.0086777	.0093923	.0057261
Skewness	: .12847	-.59331	-.24059	-.51691	-.29407
Kurtosis - 3	: 13.4360	3.1954	10.7522	3.7577	4.5634
Coef of Variation:	13.5213	26.9331	76.3043	361.7293	142.6075

Table 2: Descriptive statistics of the data

The purpose of this research is to conduct an exploratory study on whether there exists incentive for Islamic asset managers and mutual funds to invest part of their portfolio in cryptocurrency. Bitcoin is one of the most actively traded form of cryptocurrency, hence Bitcoin price index obtained from Coindesk will be used as its proxy. The empirical analysis starts by identifying the relationship between the stock markets and Bitcoin returns for possibilities of diversifying an investment portfolio.

Should Islamic Stock Market Investors Invest in Bitcoins to Gain Portfolio Diversification Benefits?

We run an M-GARCH-DCC analysis on the Bitcoin returns and all 4 stock index returns. Figures 1 and 2 illustrate the results. The results from Normal DCC Model and the t-DCC model is compared to determine the best model. The volatility parameters observed in the Normal DCC Model is highly significant with its high t-ratio and shows volatility decay with its λ_i , $i = 1, 2, 3, 4, 5, 6$ close to 1. Estimated unconditional volatilities and correlations are reported within the lower panel.

```

Multivariate GARCH with underlying multivariate Normal distribution
Converged after 51 iterations
*****
Based on 1045 observations from 01-Jan-13 to 02-Jan-17.
The variables (asset returns) in the multivariate GARCH model are:
BITCOIN DJIDEV DJIEM DJIU FBMSHA
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.
*****
Parameter              Estimate          Standard Error      T-Ratio[Prob]
lambda1_BITCOIN         .77914           .023617             32.9908[.000]
lambda1_DJIDEV           .74997           .036882             20.3340[.000]
lambda1_DJIEM            .86365           .023969             36.0322[.000]
lambda1_DJIU             .79845           .043995             18.1488[.000]
lambda1_FBMSHA           .85356           .030738             27.7688[.000]
lambda2_BITCOIN          .19171           .019676              9.7431[.000]
lambda2_DJIDEV           .12419           .017596              7.0576[.000]
lambda2_DJIEM            .10743           .014932              7.1943[.000]
lambda2_DJIU             .096599          .015151              6.3759[.000]
lambda2_FBMSHA           .10588           .018577              5.6998[.000]
delta1                   .97130           .0078239            124.1457[.000]
delta2                   .0092114         .0020433             4.5081[.000]
*****
Maximized Log-Likelihood =    17382.3
*****

      Estimated Unconditional Volatility Matrix
1045 observations used for estimation from 01-Jan-13 to 02-Jan-17
Unconditional Volatilities (Standard Errors) on the Diagonal Elements
Unconditional Correlations on the Off-Diagonal Elements
*****
      BITCOIN    DJIDEV    DJIEM    DJIU    FBMSHA
BITCOIN    .056052   -.028280   .0019164   -.028412   -.015218
DJIDEV     -.028280    .0070549    .56578    .75349    .26677
DJIEM      .0019164    .56578    .0086742    .56346    .50240
DJIU       -.028412    .75349    .56346    .0093878    .26025
FBMSHA     -.015218    .26677    .50240    .26025    .0057235
*****

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Table 3: Maximum likelihood estimates of the Normal DCC model on stock indices daily returns.

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Multivariate GARCH with underlying multivariate t-distribution
Converged after 29 iterations
*****
Based on 1045 observations from 01-Jan-13 to 02-Jan-17.
The variables (asset returns) in the multivariate GARCH model are:
BITCOIN DJIDEV DJIEM DJIU FBMSHA
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.
*****
Parameter                Estimate          Standard Error      T-Ratio[Prob]
lambda1_BITCOIN          .75652           .027245             27.7673[.000]
lambda1_DJIDEV           .78909           .041960             18.8058[.000]
lambda1_DJIEM            .90147           .025148             35.8471[.000]
lambda1_DJIU             .79968           .046034             17.3713[.000]
lambda1_FBMSHA           .81044           .048035             16.8718[.000]
lambda2_BITCOIN          .22737           .024506              9.2780[.000]
lambda2_DJIDEV           .096853          .018554              5.2200[.000]
lambda2_DJIEM            .068578          .014952              4.5867[.000]
lambda2_DJIU             .084794          .015994              5.3016[.000]
lambda2_FBMSHA           .12495           .026615              4.6945[.000]
delta1                   .97411           .0070864            137.4626[.000]
delta2                   .010164          .0022608             4.4956[.000]
df                       5.9229           .36226              16.3501[.000]
*****
Maximized Log-Likelihood = 17665.8
*****
df is the degrees of freedom of the multivariate t distribution

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```

Estimated Unconditional Volatility Matrix
1045 observations used for estimation from 01-Jan-13 to 02-Jan-17
Unconditional Volatilities (Standard Errors) on the Diagonal Elements
Unconditional Correlations on the Off-Diagonal Elements
*****
BITCOIN    DJIDEV    DJIEM    DJIU    FBMSHA
BITCOIN    .056052  -.028280 .0019164 -.028412 -.015218
DJIDEV     -.028280 .0070549 .56578   .75349   .26677
DJIEM      .0019164 .56578   .0086742 .56346   .50240
DJIU       -.028412 .75349   .56346   .0093878 .26025
FBMSHA     -.015218 .26677   .50240   .26025   .0057235
*****

```

Table 4: Maximum likelihood estimates of the t-DCC model on stock indices daily returns.

Next, the t-DCC model result shows significant signs of gradual volatility decay as well but to determine the most appropriate model will depend on:

1. maximized log-likelihood value of $17,665.8 > 17,382.3$
2. estimated degrees of freedom for the t-DCC is under 30

Hence, t-DCC model will be more appropriate to capture the fat-tailed nature of the returns. The evidence of gradual volatility decay simply means that the riskiness involved in the returns gradually cancels out following a shock in the market. The sum of

Lambda1_BITCOIN and lambda2_BITCOIN($0.77914 + 0.19171 = 0.97085$) and also the other five remaining indices, the result of the summation is under 1 which tells us that the volatility of Bitcoin return along with other returns are not following the Integrated Generalized Auto Regressive Conditional Heteroskedasticity (IGARCH) or simply, shock to the volatilities are not permanent. In the event of a shock to the system, we want to know if these correlations and volatiles revert back to normal. We then test the hypothesis whether volatility in returns are mean reverting. To achieve this we test the null hypothesis that:

$$H_0: \lambda_1 + \lambda_2 = 1$$

The summarised results in Table 5 below:

Table 5: Estimates the null hypothesis that $H_0: \lambda_1 + \lambda_2 = 1$			
	$1 - \lambda_1 - \lambda_2$	Standard Error	T-ratio
BITCOIN	.016108	.0038724	4.1598
FBMSHA	.064618	.025050	2.5796
DJIDEV	.11406	.030265	3.7687
DJIEM	.029952	.013071	2.2914
DJIU	.11553	.035953	3.2134

The diagonal elements in Table 4 (lower panel) explain the unconditional volatilities of the indices while the off-diagonals explain the unconditional correlations.

In this study, we found that Bitcoin is the most volatile with unconditional volatility of 0.056 while the remaining stock indices having very low unconditional volatilities ranging from 0.0057 to 0.0094, that in turn signifies on overall that these returns on the four Shari'ah compliant stock indices are less volatile. The least volatile of all is FTSE Bursa Malaysia EMAS Shari'ah followed by Dow Jones Islamic Developed Markets. As we know that the major financial crisis happened in 2008, and the time series data for this study is of 2013 onwards, hence we believe that the Islamic and non-Islamic stocks alike have been more cautious with its leverage levels which resulted in low volatilities.

The off-diagonal elements showing the unconditional correlations as presented in Table 4 (lower panel), it is found that correlation between DJI Europe index returns with DJI Dev index returns to be the highest among the other returns with +0.75349. The result is as

expected due to large portion of stocks in DJI Europe by virtue of weight are from the UK as identified by Najeeb et al (2015), which is also categorised as a developed market.

Being highly correlated with one another, it also came to no surprise that the lowest correlation is between the returns of the Bitcoin index with DJI Europe and DJI Dev which is -0.028. From here, we observed that Bitcoin will make an excellent diversification instrument as its correlation with all other Islamic indices in this study are extremely low as compared to correlations between stock indices. This shows that Islamic investors can benefit from diversifying their investments beyond the equity market, and into cryptocurrency i.e. Bitcoin.

In Figure 1 below, we can see the charts of conditional volatilities plotted during our entire period of study. The chart is able to confirm the time-varying properties of volatilities and correlations. As we can see from the chart that Bitcoin's conditional volatilities hit a peak in 2013 and continued to fluctuate in a volatile manner in long run as compared to Islamic stock indices. The chart also confirms what was shown in the unconditional volatility matrix earlier that is Bitcoin returns exhibited the highest volatilities as compared to other indexes during all periods. Never once did Bitcoin volatility were lower than other indices. However, small spikes in volatility from DJI Emerging Market can be seen in the mid-2013 and mid-2015 that also affected Bitcoin volatilities, hence prove its positive correlation. All other indices except DJI Emerging Markets have negative correlation with Bitcoin.

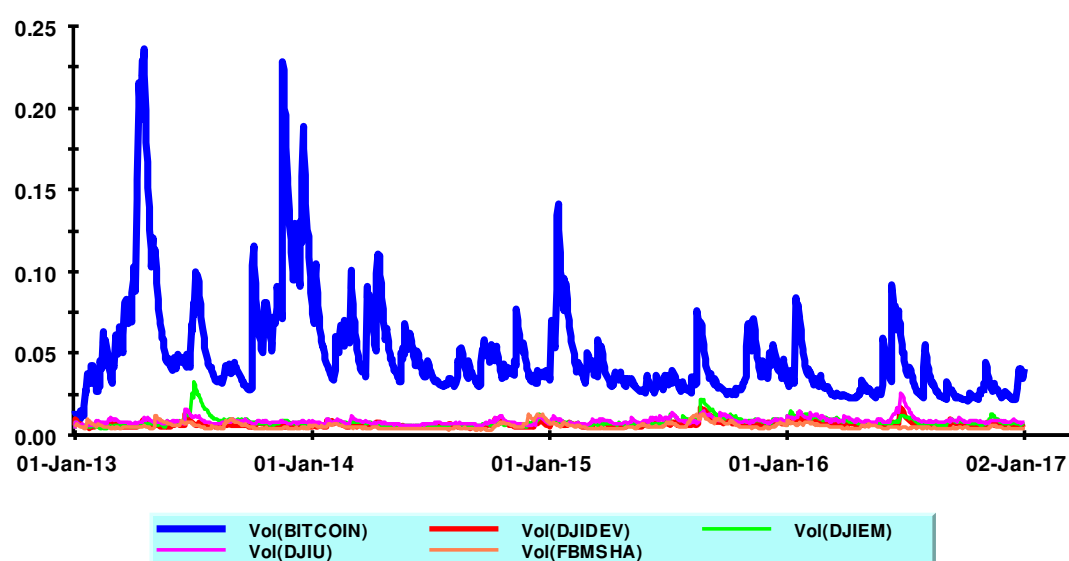


Figure 1: Conditional volatilities-BITCOIN, DJIDEV, DJIEM, DJIU, FBMSHA

Next, we plot the conditional correlations in Figure 2 and it consistently confirms the results of the unconditional correlations in Table 4 (lower panel) showing that all stock indices used in this study have an average of below zero correlation with Bitcoin except for DJI Emerging Market. With the exception for early 2013 where correlations are high between DJI Developed Market and Bitcoin, the remaining period remains low and below zero, almost similar with DJI Europe-Bitcoin correlation. The chart shows that in the period of study, correlations stays within 0.10 and -0.15 range, an average of less than zero, indicating Bitcoin is useful for diversification especially for Islamic stock investors.

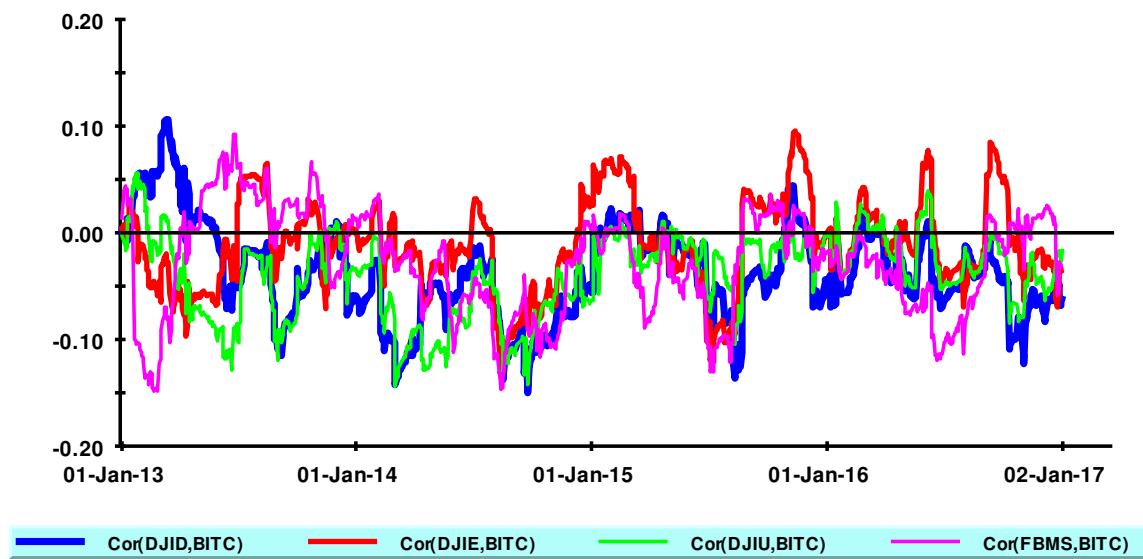


Figure 2: Conditional correlations-EMAS,MSCHN,MSSG, FTJPN, FTUSA,MSTHAI.

Continuous Wavelet Transform (CWT)

In this section, we perform continuous wavelet transform analysis using the wavelet coherence method to analyse the impacts on portfolio diversification benefits given the different investment horizons. The continuous wavelet transform and phase difference of Bitcoin price index returns with index returns of DJI Developed Market, DJI Emerging Market, DJI Europe and FBM Shari'ah EMAS are presented in Figs. 3 to 6 respectively from scale 1 (2-4 days) up to scale 7 (256 days). The horizontal axis represents the time in terms of number of trading days while the vertical axis refers to the investment horizon. The values for the 5% significance level represented by the curved line were obtained from the Monte Carlo simulations and observations outside the curved line is insignificant to this study. The colour code for power or strength of correlation ranges from blue (low coherency, near zero) to red (high coherency, near one). The arrows pointing to the right

mean that the indexes are in-phase but if they point to the left it means that the indices are out of phase. To the right and up means that the first series (BITCOIN) is lagging. To the right and down means that the first series (BITCOIN) is leading. To the left and up indicates that the first series (BITCOIN) lags, whereas first series (BITCOIN) leads when the arrows are pointing towards the left and down (Madaleno and Pinho, 2010).

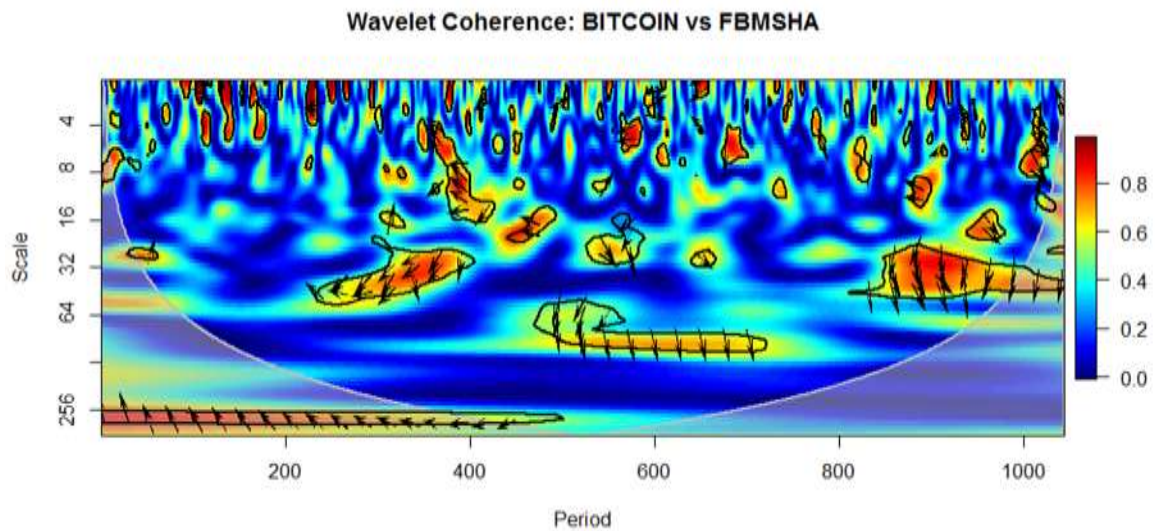


Figure 3: Continuous wavelet transform-BITCOIN and FBMSHA

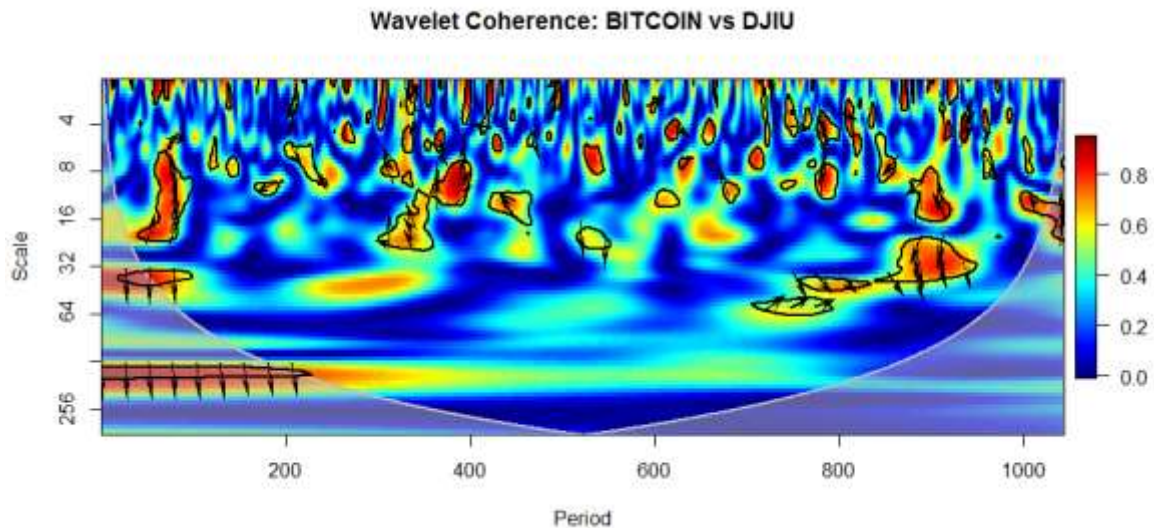


Figure 4: Continuous wavelet transform-BITCOIN and DJIU

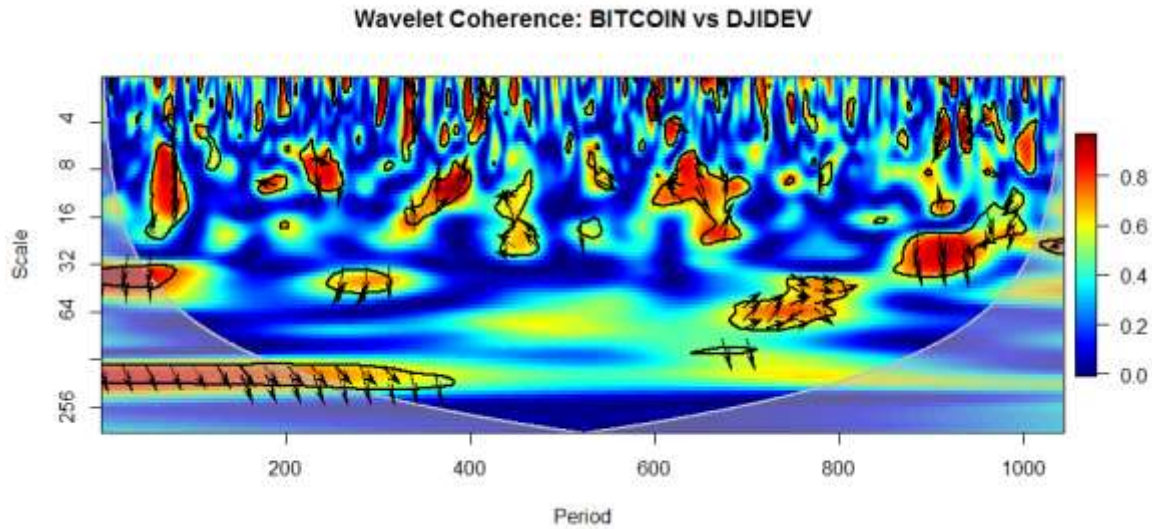


Figure 5: Continuous wavelet transform-BITCOIN and DJIDEV

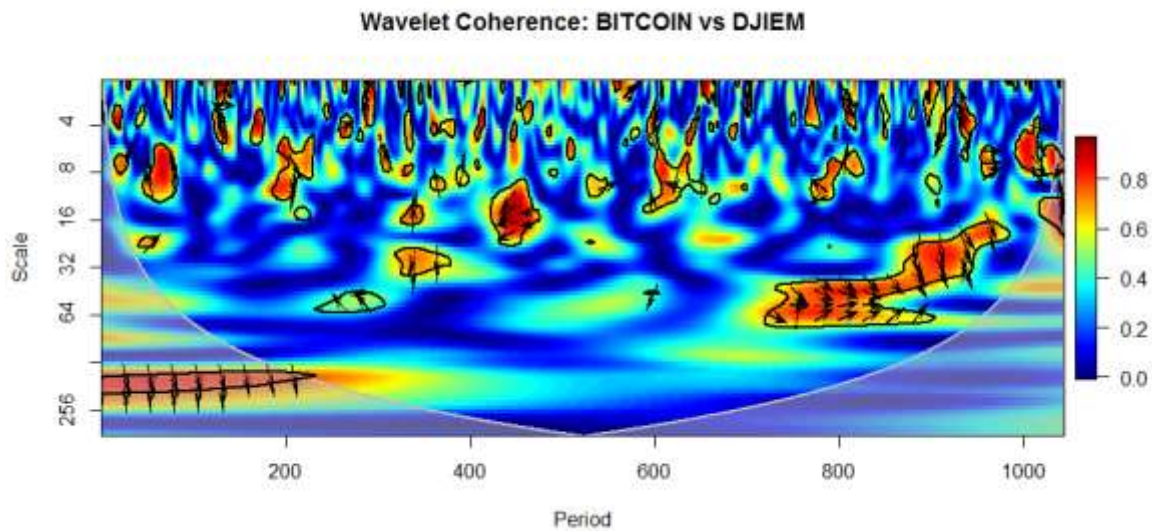


Figure 6: Continuous wavelet transform-BITCOIN and DJIEM

In general, the colour of wavelet coherence result for all 4 Figures are mostly blue in colour, which implies low coherency between Bitcoin and Islamic stock indices. With exception for short holding periods of 2-4 days which we can observe some red signals, but not much. Significant signals are:

1. around time period of 400th day and at holding period of 8-16 days
2. Time period of 900th day with holding period of 16-32 days and 32-64 days

Whereby all indices are showing a similar result of slightly high correlation with Bitcoin. Apart from the above periods observed which showed similar and distinct correlation with Bitcoin returns, all other periods of moderate to high correlation with Bitcoin are hardly noticeable. Long investment holdings of 64-128 days shows low correlation on most periods for all Islamic stock indices. This could imply that Bitcoin can provide diversification even to Islamic stock investors who have different holding period of investments (long and short term investors)

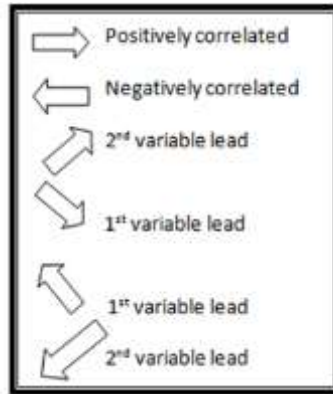


Figure 7: lead-lag arrow rubric

Robustness and Validation of Results – MODWT

Maximum Overlap Discrete Wavelet Transform (MODWT) approach is used for the robustness and validation of the results in Multivariate Generalized Autoregressive Conditional Heteroskedasticity-Dynamic Conditional Correlation (MGARCH-DCC) and Continuous Wavelet Transform (CWT). In MODWT, the result will be specified the time scales for the returns whereby this study had extended the scaling into seven scales (2-4 days, 4-8 days, 8-16 days, 16-32 days, 32-64 days, 64-128 days and 128-256 days). The correlations between the BITCOIN index returns with the index returns of Shari'ah indices used in this study are examined using the generated MODWT returns series and the results are shown in the table below.

MODWT Scaling	FBMSHA	DJIU	DJIDEV	DJIEM
2-4 days	-0.02183016	-0.047515697	-0.08662398	0.01989142
4-8 days	0.02154318	0.007865267	-0.001067655	-0.01836495
8-16 days	-0.04061747	-0.06111409	-0.007172127	-0.02300642
16-32 days	-0.10688815	-0.034307245	-0.008103428	0.05242465
32-64 days	-0.09925462	-0.008231172	0.085895635	0.0334505
64-128 days	0.13122073	0.338284362	0.456946746	0.18320457
128-256 days	0.31674619	0.477741929	0.518077679	0.67269254

Table 6: Wavelet correlations of Bitcoin index returns with returns of the 4 indices used in this study-MODWT transformations.

There are negative correlations across all Shari'ah indices but DJI Emerging Market is only negatively correlated for holding period of 4-8 days and 8-16 days, the rest of the holding periods are positively correlated. For all indices, holding period of 64 days onwards tend to have positive correlation with Bitcoin. Unlike findings for correlation between stock indices and conventional commodities that tend to be more highly correlated in the longer scale, there is no predicted trend for relationship of Bitcoin with Shari'ah stock indices of different holding periods. For holding period of 8-16 days, correlation are negative for all indices indicating that investors should look into Bitcoin as diversification for short-medium term investment horizon. As for long term investors in DJI Developed Market and DJI Emerging Market, its correlations with Bitcoin is seemingly high at scale of 128-256 days which is above 0.5, however it is still better than results from Najeeb et al (2015) where correlations of FBMSHA with other Shari'ah indices goes above 0.7 when holding period is at 64-128 days.

6. Conclusion

The study examines empirically the causal links between the Bitcoin return volatility and Shari'ah indices (FBM EMAS, DJI Developed Market, DJI Emerging Market & DJI Europe) by using daily data from January 2013 to January 2017. The knowledge on the relationship between the seemingly controversial cryptocurrency and Islamic equity markets would be helpful to identify the potential use by Islamic investors or mutual fund managers for portfolio diversification. On the whole, this study is formed by combining recent interests in 3 areas of finance: Islamic finance, digital currency and latest econometric techniques. Related literature discussing the theoretical foundation of the relationship of Shari'ah indices around the world with Malaysian EMAS index (Najeeb et al, 2015) and Shari'ah indices with venture capital investment (Jafar & Masih, 2014) inspired this study in using Bitcoin as a potential diversifier. This study is concluded to three key findings on the basis of empirical evidence. Firstly, there is low and negative correlation between Malaysia's Shari'ah stock market and Bitcoin, this implies that investors in Malaysia can gain portfolio diversification benefit by investing in Bitcoin. Secondly, correlation between DJIDEV, DJI Europe & DJIEM with Bitcoin is low and negative as well with the exception for long-term holdings. Although correlation is increasing at higher holding period between stock market and Bitcoin, the correlation is still lower than findings from earlier articles on cross border diversification. Finally, as correlation of Bitcoin and stock indices increases along with holding period horizon,

this implies that Bitcoin prices is in fact driven by long-term fundamentals rather than short-term and speculative.

It is recommended for the future empirical research extend to focus on other stock market indices and a more exhaustive study that may include socially responsible index as a substitute for Islamic stock index. The further study is encouraged to analyze other factors including macroeconomic variables and fundamental factors. It may be useful to also look into a more robust explanation from Shari'ah scholar's perspective on the validity of Bitcoin in order to advocate for the legal tender of Bitcoin currency in Malaysia and other Islamic countries.

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